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BIOLOGICAL DECONTAMINATION METHODS APPLICABLE TO CIVIL DEFENSE

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ABSTRACT

Decontaminating procedures that are available to the public following a biological attack are presented. They include steps to decontaminate skin, clothing, food, water, equipment, building interiors, terrain, and accidental spills of pathogenic microorganisms.

Exposure to a biological agent attack does not necessarily mean that all objects we handle or contact must first be sterilized. The residual microorganisms on these objects will die at various rates, depending on the type of microorganism, the nature of the surface, the amount of exposure to sunlight, the temperature, the relative humidity, and other factors. The decision to carry out decontamination procedures will be made by Civil Defense officials, who will then inform the individual what and how to decontaminate.

There are numerous decontamination procedures that an individual can employ in his own household. Other procedures are available, but they should be used only by trained Civil Defense personnel. Many of the procedures developed by Decontamination Section of Protection Branch, Physical Defense Division, that are applicable to individual and/or large-scale use will be discussed in this manuscript. These include procedures for decontaminating skin, clothing, food, water, equipment, building interiors, and terrain.

We have tested the effectiveness of a number of commonly available household solutions as skin disinfectants and found four of them, hydrogen peroxide, vinegar, acidified hypochlorite, and detergent-iodine complex, to be effective decontaminants (Table I) when applied to skin contaminated by vegetative-type bacteria. Nonacidified hypochlorite, rubbing alcohol, witch hazel, and commercial bleach-detergent solution were less reliable as skin-decontaminating agents. If none of these solutions is available at the time of need, tests have shown (Table II) that many of the contaminating microorganisms can be removed from the skin by washing with water, soap and water, commercial towelettes or hand cleaners, or by merely wiping the skin with a dry paper towel. Showering with vigorous scrubbing will effectively reduce the degree of body bacterial contamination. Our tests have shown that about 90 per cent of the organisms are removed by ordinary showering, but about 99 per cent can be removed by vigorous scrubbing with soap and water.

In co-operation with the Quartermaster Corps, a modified decontamination procedure for large-scale laundering was developed. This study revealed that incorporating 2000 parts per million (ppm) of available chlorine to the first suds reduced the level of bacterial spore contamination on clothing more than did the standard laundering procedure (Table III). Undoubtedly, much less chlorine could be used for clothing that is contaminated with vegetative microorganisms. The use of a disinfectant, such as hypochlorite, in the wash cycle alleviates the need to treat the contaminated wash water after laundering. Similar procedures could also be set up for home use. Alternate methods of decontaminating clothing include soaking in hypochlorite solution or boiling in water for five or ten minutes.

TABLE I. PER CENT REDUCTION OF *S. MARCESCENS* AND *S. CITREUS* ON HUMAN SKIN EXPOSED TO SOME COMMON HOUSEHOLD SOLUTIONS

SOLUTION	RANGE PER CENT BACTERIAL REDUCTION[a]	SAMPLES WITH 50 PER CENT OR MORE BACTERIAL REDUCTION
Detergent – Iodine Complex	98 - 100	12/12
Hydrogen Peroxide	94 - 99.999	12/12
Vinegar[b]	72 - 99.98	12/12
Acidified Hypochlorite[c]	68 - 99.8	12/12
Hypochlorite[d]	0 - 99	9/12
Rubbing Alcohol	0 - 99.99	8/12
Witch Hazel	0 - 99.8	6/12

a. Results for both microorganisms.
b. Contained 4.9 per cent acetic acid.
c. 4.0 milliliters Clorox, 4.0 milliliters vinegar, and 1 liter of water.
d. 4.0 milliliters of Clorox in one liter of water.

TABLE II. EFFECTIVENESS OF PHYSICAL METHODS FOR REMOVING *B. SUBTILIS* VAR. *NIGER* SPORES FROM HUMAN SKIN

METHOD	RANGE PER CENT BACTERIAL REDUCTION	SAMPLES WITH 50 PER CENT OR MORE BACTERIAL REDUCTION
Commercial Towelette	60 - 80	3/3
Commercial Hand Cleaner	58 - 91	3/3
Soap and Water	57 - 89	3/3
Water	43 - 92	2/3
Dry Paper Towel	67 - 82	2/2

TABLE III. PER CENT REDUCTION OF B. SUBTILIS VAR. NIGER SPORES ON ARMY CLOTHING AFTER WASHING BY THE STANDARD AND MODIFIED LAUNDRY PROCEDURES

ITEM	BACTERIAL REDUCTION, PER CENT	
	STANDARD LAUNDRY PROCEDURE	MODIFIED PROCEDURE[a]
Cotton sateen, water-repellent	95.5	99.9
Cotton warp, nylon-filled, oxford	96.6	99.9
Cotton poplin	84.7	99.6
Wool shirting and wool nylon, serge	98.8	98.8
Cotton sateen, impregnated	96.8	99.999
Cotton poplin, impregnated	99.4	99.997

a. Hypochlorite added in sufficient concentration to give 2000 ppm available chlorine.

Much work has been performed in our laboratory using ethylene oxide to decontaminate clothing. From this work, methods have been developed and published for sterilizing clothing and other items in readily available plastic bags, with ethylene oxide supplied in ordinary aerosol bomb-type cans. Such a procedure requires six to eight hours at a temperature above 60°F. The use of this procedure is best left to trained Civil Defense personnel. On a large scale, beta-propiolactone vapor could be used to sterilize clothing hanging in a large room. Here again is a job for trained personnel.

Contaminated water is nothing new to us. Since all natural waters used for municipal water supplies are considered potentially contaminated, they are given some sterilization treatment. If the municipal water supply is not damaged by an enemy attack, obtaining purified water should not be a problem following exposure to an aerosol of a biological agent, because the regular water sterilization procedures will most likely provide an adequate treatment. If the municipal water supply has been disrupted by enemy activity, urban residents will have to apply their own sterilization measures to whatever water they can get. Adequate measures include boiling, treating with chemicals, and filtering. Satisfactory chemicals for this purpose, bleach and iodine, are generally found in the home.

A few drops of household bleach or tincture of iodine added to each quart of water and allowed to stand 30 minutes will provide safe water; boiling water for five to ten minutes will also suffice. If the individual has one of the small, commercially available water pumps with a charcoal — silver salt filter, it can be used. We have tested several such pumps and found them to be quite satisfactory for sterilizing even highly contaminated water.

Techniques for sterilizing some foods have been investigated by our group. These studies show that the exterior surfaces of large volumes of foods packed in impermeable packages can be sterilized by vapor disinfectants such as beta-propiolactone, ethylene oxide, methyl bromide, or formaldehyde. In this respect, tests were performed in cooperation with the Food and Drug Administration, using refrigerated food-transport vans as sterilization chambers for the treatment of large quantities of food. Carboxide, methyl bromide, and formaldehyde were used and found to be satisfactory decontaminants. Other tests revealed that the semitrailer van is a satisfactory chamber in which to sterilize packaged food with formaldehyde vapor. Ethylene oxide and methyl bromide are too penetrating to be used in the ordinary semitrailer van; however, beta-propiolactone, like formaldehyde, could be used satisfactorily. A project we performed for the US Navy Bureau of Supplies and Accounts revealed that food in cans, bottles, and even many fresh vegetables such as potatoes, lettuce, cabbage, etc., can be decontaminated by immersing for five minutes in hypochlorite solution containing about 0.2 per cent available chlorine (Table IV). The same project showed that baking can also effectively reduce contamination in some foods (Table V). It is easier to sterilize the interior of bread and other baked goods than to sterilize the surface coating. Boiling and roasting are effective for decontaminating foods. As a result of this initial study at Fort Detrick, plus more detailed studies of their own, the US Navy prepared emergency menus for use in the event of a biological agent attack. Such menus and procedures can also be used in the home.

TABLE IV. PER CENT REDUCTION OF *B. SUBTILIS* VAR. *NIGER* SPORES EXPOSED ON FOODSTUFFS TO A HYPOCHLORITE[a] DIP FOR FIVE MINUTES

ITEM	REDUCTION, Per Cent	APPEARANCE
Apples	100	No change
Potatoes	99.8	No change
Eggs in crate	99.98	No change
Lettuce	99.9	Slightly bleached, but edible
Can, exterior	100	No change
Meat, frozen	95	Slightly thawed

a. Available chlorine = 2000 ppm, pH = 6.5.

TABLE V. PER CENT REDUCTION OF B. SUBTILIS VAR. NIGER SPORES AS A RESULT OF BAKING

ITEM	BAKING TIME AND TEMPERATURE	REDUCTION, PER CENT	
		EXTERIOR SURFACE	INTERIOR
Bread	40 min 400°F	99.0	100
Pancakes	3 min[a]	99.8	99.5
Muffins	25 min 425°F	99.998	100
Biscuit	15 min 425°F	99.995	100

a. Temperature not recorded.

Ordinary homes, factories, and office buildings offer little protection against the penetration of microbiological aerosols. These enclosures, however, can be decontaminated by applying vapor-phase disinfectants such as beta-propiolactone or formaldehyde. Beta-propiolactone is more effective because it is faster-acting and requires less aeration time before one can re-enter a building following its use. Procedures for the treatment of large enclosures have been developed and published by our group. A complete sterilization cycle with beta-propiolactone, including aeration of the enclosure, can be accomplished within eight hours if there is adequate ventilation. Formaldehyde will take 24 hours, if not longer, for a complete treatment, including aeration. Aeration is a big factor after using formaldehyde to decontaminate an enclosure because the chemical, when sprayed, deposits on surfaces and polymerizes. This polymer slowly depolymerizes and gives off formaldehyde vapor, thus greatly extending the time required to rid an enclosure of the formaldehyde odor. Since both beta-propiolactone and formaldehyde are toxic to man in the concentrations required to sterilize enclosures, these chemicals can be used to decontaminate only noninhabited areas.

The homeowner will not be able to use beta-propiolactone or formaldehyde because of their toxicity and nonavailability. Instead, he will be limited to aerating the home by opening windows and doors, followed by scrubbing down surfaces with disinfectant solutions. Decontaminants that can be used for this purpose include hypochlorites, Lysol-type products, quaternary ammonium compounds, and some of the new detergent-iodine complexes. Undoubtedly, vinegar and hydrogen peroxide can also be used to decontaminate some surfaces. In their absence, one can use soap and water. More work should be performed in this area to develop adequate decontamination procedures for the household.

We are also actively investigating the development of self-sterilizing surface coatings applicable as paints, waxes, etc. for walls, floors, furniture, etc. There are many so-called self-sterilizing paints and waxes currently on the market; however, their effectiveness leaves much to be desired. All of the commercial products that we have evaluated are ineffective, unless the surrounding humidity is at least 98 per cent. We have yet to find one that is effective at normal humidities.

Studies in our laboratory show that slowly volatile disinfectants such as paraformaldehyde, when incorporated in paint, produce surface coatings that are bactericidal at normal relative humidities. The use of a volatile chemical does mean, however, that the self-sterilizing activity of the surface coating will not last too long.

Equipment may be contaminated either by a primary or secondary aerosol of a biological agent. Experiments that we performed in co-operation with the Corps of Engineers showed that Army trucks became contaminated by a secondary aerosol to an extent proportional to the concentration of organisms on the terrain over which the vehicles are operated. These tests also showed that the extent of secondary aerosol is a function of the type of surface, whether dirt, macadam, or concrete, over which the vehicles traveled. The need for decontamination of equipment will depend on many such factors as extent of contamination, the time one can allow prior to reusing the equipment, and the other factors mentioned previously.

Ethylene oxide has been used successfully to sterilize small equipment under tarpaulins, but it is too expensive for treating large equipment. An exposure of about eight hours at 60°F or above was sufficient when 30 pounds of ethylene oxide was used for each 1000 cubic feet of space. As described above for clothing decontamination, ethylene oxide can be used satisfactorily to sterilize small equipment in gastight bags. Ethylene oxide gas is very effective for this purpose and yet is noncorrosive. We have been successful in sterilizing large equipment under a tarpaulin with formaldehyde vapor. Beta-propiolactone could also be developed for this purpose. Washing with water can be used to reduce contamination on motor vehicles and other equipment. Ordinary washing has been shown to reduce the contamination on vehicles by about 90 per cent. Washing with vigorous scrubbing reduces the level of contamination 95 to 99 per cent. Such a procedure, however, does not kill the microorganisms; it merely washes them off the surface of the equipment and onto the ground. The use of bleach solution in the wash water will help to decontaminate the items. Bleach can also be used to decontaminate the ground after washing the equipment.

The decontamination of a large area of terrain is not generally practical because of the problem of stockpiling tremendous quantities of decontaminants, as well as the numerous pieces of apparatus required to apply the chemical. Manpower for applying the decontaminant will also present a great problem. Thus the decontamination of large areas will be a function of weathering. Small areas can be treated with hypochlorite, sodium hydroxide, or beta-propiolactone. Some terrain could be turned over by plowing, to decrease the hazard from contamination. We have found that water greatly reduces the amount of secondary aerosol that can be generated. The water treatment, however, is effective only as long as the terrain is wet; when it dries out again, the hazard is renewed. Oil is a better suppressant, because it does not readily evaporate.

There are many decontamination methods available for treating personnel, food, water, equipment, etc., and, although developed for military use, they are applicable to civil defense. Other techniques better adapted to home use could probably be developed. However, less emphasis should be placed upon the need for specialized civil defense equipment or trained personnel. The integration of protective measures with other aspects of civil defense, such as defense against chemical or radioactive fallout, should also be considered.